# PATENT SPECIFICATION

**803,452**

*Date of Application and filing Complete Specification: Sept. 21, 1956.*

*No. 28994/56.*

*Application made in United States of America on Sept. 22, 1955.*

*Complete Specification Published: Oct. 22, 1958.*

**Index at acceptance:—Classes 83(2), A166; 83(4), S3; and 122(5), B13C(1: 6).**

**International Classification:—B23k, p. F06j.**

COMPLETE SPECIFICATION

## Improvements in or relating to Labyrinth Seals

SPECIFICATION NO. 803,452

By a direction given under Section 17 (1) of the Patents Act 1949 this application proceeded in the name of Canadian Patents and Development Limited, a Canadian company, of National Research Building, Sussex Street, City of Ottawa, County of Carleton, Province of Ontario, Canada.

THE PATENT OFFICE,
21st November, 1958

DB 08862/1(7)/3700 150 11/58 R

to the passage of high pressure gas into regions of relatively low pressure. Because of the high differential in speeds between adjacent relatively rotating parts it is customary to use seals of the labyrinth type which are well known in the art. Labyrinth seals consist essentially of a series of axially spaced circumferential baffles or rings mounted on either of the relatively rotating parts and extending towards the other part so that the peripheral space between the outer circumference of the said rings and the other part is as small as is practicable. The high pressure gas or vapour passing through this space at each ring experiences a drop in pressure so that after passing the successive rings which constitute the seal, the gas or vapour has fallen substantially to the pressure of the gas on the low pressure side of the seal.

It will be apparent from the preceding description that it is advantageous for the space between the outer periphery of each ring and the adjacent relatively rotating surface to be as small as possible. In practice, however, the components of all rotary power conversion machines are subject to distortion due to centrifugal forces, temperature variations, and, particularly in the case of gas turbines engine, to acceleration and gyroscopic forces necessitating certain minimum clearance between the rings and the adjacent relatively moving surfaces so as to avoid rubbing contact.

In gas turbine engines of the type commonly

one edge than at the other, that is each crimp is formed by displacing the material from which the seal element is made to a greater extent at one edge of the strip than at the other, to cause the strip to conform to a circular or helical form.

The invention also consists in labyrinth seals and methods of making labyrinth seals using the above disclosed construction of labyrinth seal element.

In order that the present invention may be more clearly understood reference will now be made, by way of example, to the accompanying drawings in which:—

Figure 1 is a side elevation view of a gas turbine engine employing labyrinth seals constructed in accordance with this invention;

Figure 2 is a detailed perspective view of a portion of Figure 1 showing the labyrinth seal with portions broken away to show the construction;

Figure 3 is a plan view of one of the strip seals of the invention;

Figure 4 is a section through line 4—4 of Figure 3 showing the method of securing the strip seal in position; and

Figure 5 is a diagrammatic view of a strip before and after crimping, the strip before crimping being shown in dotted lines.

In the drawings, a gas turbine engine 10 of the aircraft type is illustrated, by way of example only, with portions cut away to show three bearing supports for the main rotor shaft. The bearing supports are indicated at reference

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Price

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COMPLETE SPECIFICATION

## Improvements in or relating to Labyrinth Seals

I, PETER DENNIS COMERY, of Orenda Engines Limited, of the Village of Malton, County of Peel, Province of Ontario, Canada, a Canadian citizen, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to labyrinth seals used in gas and steam turbine engines and like rotary power conversion machines.

In various places in such rotary power conversion machines in which a vapour or gas is used as the working fluid, it is often necessary to provide seals between the relatively rotating parts or members in order to provide a barrier to the passage of high pressure gas into regions of relatively low pressure. Because of the high differential in speeds between adjacent relatively rotating parts it is customary to use seals of the labyrinth type which are well known in the art. Labyrinth seals consist essentially of a series of axially spaced circumferential baffles or rings mounted on either of the relatively rotating parts and extending towards the other part so that the peripheral space between the outer circumference of the said rings and the other part is as small as is practicable. The high pressure gas or vapour passing through this space at each ring experiences a drop in pressure so that after passing the successive rings which constitute the seal, the gas or vapour has fallen substantially to the pressure of the gas on the low pressure side of the seal.

It will be apparent from the preceding description that it is advantageous for the space between the outer periphery of each ring and the adjacent relatively rotating surface to be as small as possible. In practice, however, the components of all rotary power conversion machines are subject to distortion due to centrifugal forces, temperature variations, and, particularly in the case of gas turbines engine, to acceleration and gyroscopic forces necessitating certain minimum clearance between the rings and the adjacent relatively moving surfaces so as to avoid rubbing contact.

In gas turbine engines of the type commonly used to propel present day aircraft, weight is of extreme importance and, therefore, it is desirable that a labyrinth seal should increase the weight of the engine as little as possible.

In these engines it is also desirable that the labyrinth seal be so constructed that should contact be made between the relatively rotating members due to distortion of the parts under the influence of centrifugal force, temperature variations, acceleration or gyroscopic forces, no serious damage will result.

The present invention consists in a labyrinth seal element comprising a thin metallic strip formed with crimps extending across its width, wherein each crimp is of greater magnitude at one edge than at the other, that is each crimp is formed by displacing the material from which the seal element is made to a greater extent at one edge of the strip than at the other, to cause the strip to conform to a circular or helical form.

The invention also consists in labyrinth seals and methods of making labyrinth seals using the above disclosed construction of labyrinth seal element.

In order that the present invention may be more clearly understood reference will now be made, by way of example, to the accompanying drawings in which:—

Figure 1 is a side elevation view of a gas turbine engine employing labyrinth seals constructed in accordance with this invention;

Figure 2 is a detailed perspective view of a portion of Figure 1 showing the labyrinth seal with portions broken away to show the construction;

Figure 3 is a plan view of one of the strip seals of the invention;

Figure 4 is a section through line 4—4 of Figure 3 showing the method of securing the strip seal in position; and

Figure 5 is a diagrammatic view of a strip before and after crimping, the strip before crimping being shown in dotted lines.

In the drawings, a gas turbine engine 10 of the aircraft type is illustrated, by way of example only, with portions cut away to show three bearing supports for the main rotor shaft. The bearing supports are indicated at reference

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numerals 11, 12 and 13. The labyrinth seal which is the subject of this invention is particularly adapted to be used in such a location but it is, of course, not to be construed as limited thereto.

In Figure 2 the seal 14 is illustrated as mounted on the cylindrical internal surface 15 of a member 16 which surrounds a shaft 18. While the member 16 is shown in Figure 2 as having a cylindrical inner surface, it is to be understood that a member having a tapered or conical inner surface could be used as well. In fact, any surface in which an uninterrupted helical groove may be cut is suitable for mounting the labyrinth seal of this invention. The seal consists of a thin strip 14 of suitable material, such as steel, which is set in helical form in a helical groove 17 which is cut in the surface 15 of the member 16.

The shaft 18 is rotatably supported by journal bearings (not shown) in a position such that the distance between the surface 18a of the shaft 18 and the inner edge of the steel strip 14 is as small as is practical having regard to the expansion of both the shaft and the seal under elevated operating temperatures and the displacement of the shaft under centrifugal, gyroscopic and gravitational forces encountered during operation. The distance from the surface of the shaft to the inner edge of the seal is required to be substantially constant about the circumference of the shaft.

In Figures 3, 4 and 5, a section of the seal strip 14 is shown and, in Figure 5, it can be seen how a strip 19 of thin steel may be formed with crimps 20, extending across the width of the strip, to cause same to bend in the direction indicated by the arrows 21. The crimps are of greater magnitude, that is, the dimension 24 in Figure 4, is of greater magnitude, adjacent one edge of the strip than adjacent the other so that the strip will bend in its own plane and by varying the magnitude of the crimps at one end relative to the magnitude of the same crimp at the other end, the desired radius of curvature for the strip can be determined. The crimps 20 are formed alternately in opposite directions as seen in Figure 3, the extent to which the metal is deformed to produce the crimps depending upon the radius to which the seal is desired to conform. If the radius of the supporting member for the seal is relatively large, as shown in Figure 2, the crimps are of relatively small magnitude. However, if the radius is small, the magnitude of the crimps would need to be considerably greater to enable the strip to conform to the smaller radius. The crimping of the thin steel strip greatly increases its rigidity and enables a much thinner strip to be employed than would be the case if the crimping were not done.

In Figure 4, the strip 14 is shown seated in a groove 17 cut in the surface 15 of a supporting member 16. The groove 17 is, according to the preferred construction, a helical groove (see Figure 2) although it may be replaced by a series of annular grooves spaced along the length of the shaft 18 in which case each groove will receive a separate strip 14 which is cut to such a length that the free ends of the strip will abut one another when the strip is crimped and seated in the groove. In such a construction, the strip is formed in precisely the same manner as that previously disclosed except that the length of the strip will be shorter than in the case of a helical seal.

A band 22 of brazing material occupies the bottom of the groove 17 and, under the influence of heat, will weld the lower edge 14a of the strip to the bottom of the groove to retain it in position. When the strip 14 is formed in the crimping operation, the radius which will be occupied by the strip in the "at rest" position is made somewhat larger than the radius of the surface which will support the strip so that the natural resiliency of the sealing strip 14 will tend to hold it in the groove until the welding operation is complete. This resiliency also serves to force the strip 14 against the brazing band 22 thereby imbedding itself in the brazing material as soon as the latter becomes fluid under the influence of heat.

As an alternative method, the brazing material may be replaced by or augmented with a ring 23 of similar material which lies on the surface 15 of member 16 adjacent the groove 17. Heat applied to ring 23 will cause it to melt and capillary action will cause it to flow into the groove 17 to securely weld the seal 14 in the groove.

During normal operation of the machine in which the labyrinth seals of this invention are used, the shaft 18 may be displaced radially due to the forces which are exerted thereon such as centrifugal, gyroscopic or gravitational forces on an aircraft in flight. If this displacement is sufficient to cause a rubbing contact between the surface of the shaft and the inner edge of the seal strips, this rubbing contact will, with the labyrinth seal of the present invention, be distributed axially along the surface of the shaft over an area as wide as the distance represented by the dimension 24 in Figure 4 of the drawings. This distribution of rubbing contact, when it occurs, will reduce the wear on the shaft and will retard the increase of the distance between the shaft and the seal due to wear.

From the foregoing description it will be seen that a labyrinth seal has been provided which will be less prone to wear, which will be of rigid construction and which will enable thin material to be used thereby increasing the power to weight ratio of the engine.

WHAT I CLAIM IS:—

1. A labyrinth seal element comprising a thin metallic strip formed with crimps extending across its width, wherein each crimp is of greater magnitude at one edge than at the other to cause the strip to conform to a circular or helical form.

2. A labyrinth seal comprising a series of annular grooves cut in a mounting surface, a series of annular metallic strips set therein, said strips being formed from straight strips of metal having crimps formed therein and extending across the width thereof, said crimps being of greater magnitude at ne edge than at the other to cause the strips to conform to a circular shape of predetermined radius.

3. A labyrinth seal comprising a mounting surface, an uninterrupted helical groove cut in the mounting surface, a metallic strip having crimps formed therein and extending across the width thereof, said crimps being of greater magnitude at one edge than at the other edge to cause the strip to assume a circular or helical form, said strip being seated in the groove, and means for securing the strip therein.

4. A method of making a labyrinth seal comprising the steps of cutting an uninterrupted helical groove in a mounting surface, forming crimps in, and extending across the width of, a thin strip of metal by displacing the material of the strip to a greater extent at one edge than at the other, to cause the strip to assume a helical form, seating the strip in the groove, and securing it therein by brazing.

5. A method of forming a labyrinth seal element comprising the steps of forming crimps in, and extending across the width of, a straight strip of metal by displacing the material of the strip to a greater extent at one edge than at the other to cause the strip to curve, the direction of curvature lying in the same plane as the original plane of the strip.

6. A labyrinth seal element substantially as hereinbefore described with reference to the accompanying drawings.

7. Labyrinth seals substantially as hereinbefore described with reference to the accompanying drawings.

8. Methods of making labyrinth seals substantially as hereinbefore described with reference to the accompanying drawings.

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Chartered Patent Agents.

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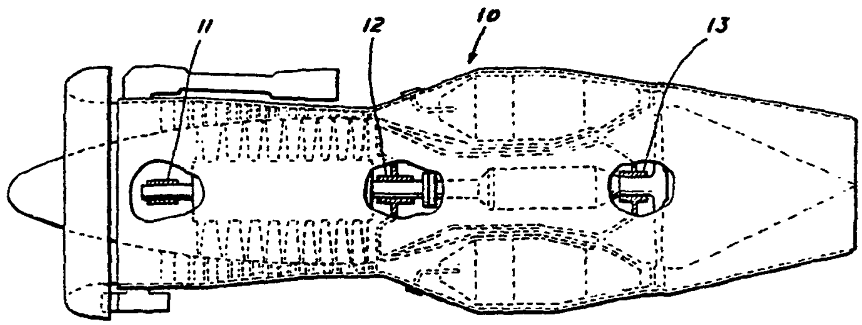


FIG. 1

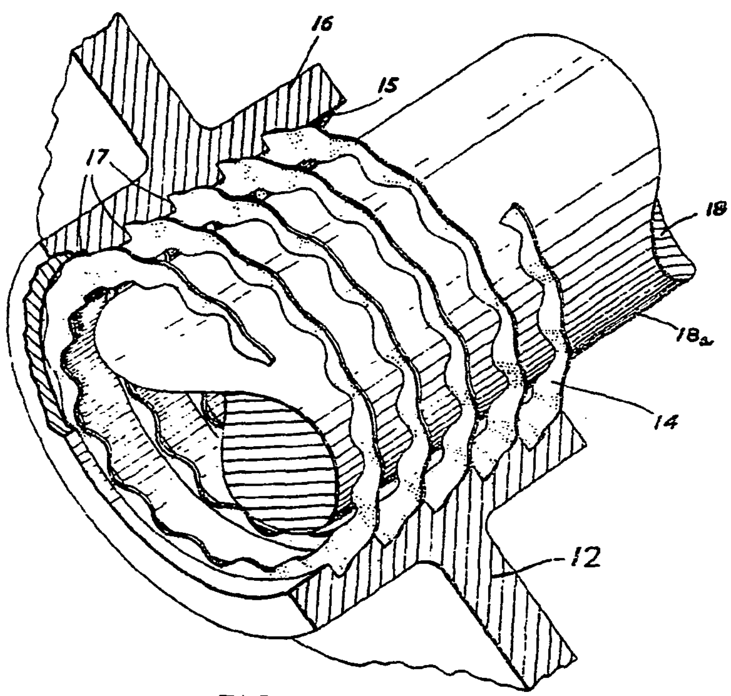


FIG. 2

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2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

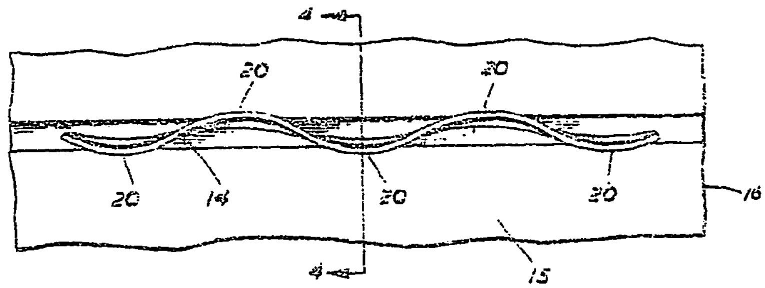


FIG. 3

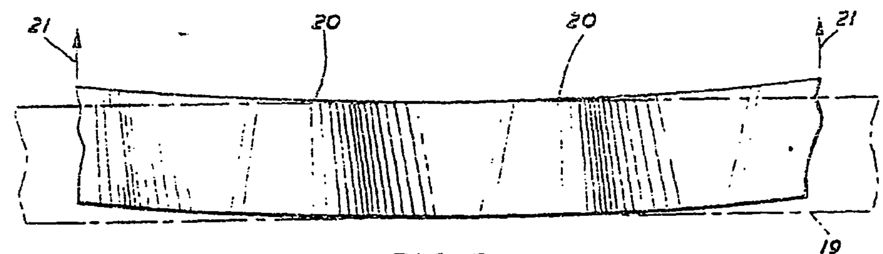


FIG. 5

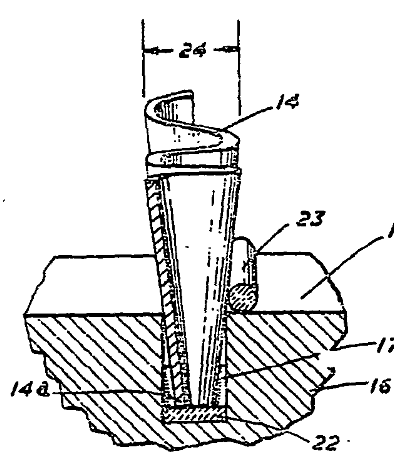


FIG. 4

803,452 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

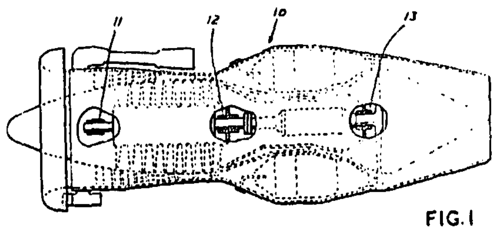

FIG.1

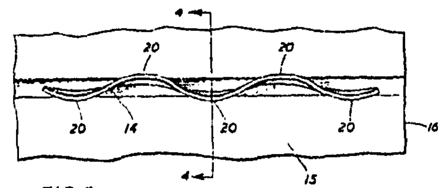

FIG.3

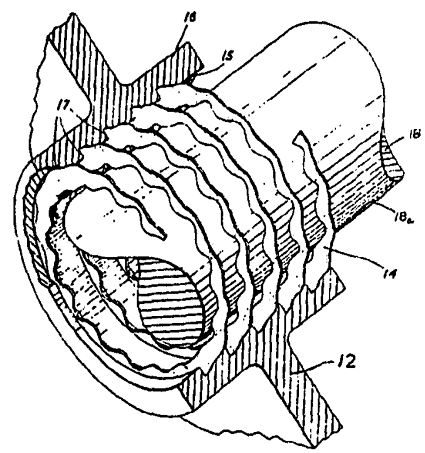

FIG.2

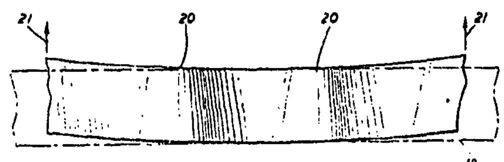

FIG.5

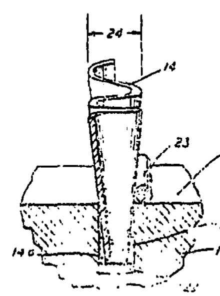

FIG.4